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THE TREATMENT OF CARBON MONOXIDE POISONING.

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Carbon monoxide poisoning is one of the most widely distributed and most frequent of industrial accidents. The gas is a product of incomplete combustion and is without color, odor, or taste; therefore, its presence is frequently unsuspected in many places where it exists. It is an ever-present danger about blast and coke furnaces and foundries. It may be found in a building having a leaky furnace or chimney or a gas stove without flue connection, such as a tenement, tailor shop, or boarding house. Hospitals receive a great number of victims of poisoning, whether by accident or in an attempt at suicide, from artificial illuminating gas. Persons may be affected by leaks wherever water gas is formed or used. The exhaust gases of gasoline automobiles contain from 4 to 12 per cent of carbon monoxide, and in closed garages men are not infrequently found dead beside a running motor. A similar danger may arise from gasoline engines in launches. The gas is formed also in stoke-rooms, in gun turrets on battleships, in petroleum refineries, and in the Leblanc soda process in cement and brick plants. In underground work carbon monoxide may appear as the result of shot firing, mine explosions, or mine fires, or in tunnels from automobile exhausts or from coal or oil burning locomotives.

Carbon monoxide exerts its extremely dangerous action on the body by displacing oxygen from its combination with hemoglobin. Hemoglobin, the coloring matter of the blood, normally absorbs oxygen from the air in the lungs and delivers it to the different tissues of the body. The affinity of carbon monoxide for hemoglobin is about 300 times that of oxygen. Because of this, even when only a small amount of the poisonous gas is present in the air breathed into the lungs, much of the hemoglobin is locked up in combination with carbon monoxide and so can not keep up its usual work of carrying oxygen to the tissues. These, because of the lack of oxygen, can not do their work properly. If they are smothered long enough, the tissue cells become damaged, and the injury to the cells may be permanent even if the patient survive. It has been asserted that carbon monoxide has a specific poisonous action on some tissues of the body, especially those of the nervous system, but there is little evidence in favor of this statement and much against it. Haggard and Henderson found that there was no change in the rate of growth of chick brain tissue, even when it was exposed to an atmosphere containing over 70 per cent of carbon monoxide, and it has been shown many times that animals without red blood (hemoglobin) can live in atmos-

¹In cooperation with the U. S. Bureau of Mines.

pheres containing high concentrations without apparent harmful effects. Recently this was demonstrated at the Pittsburgh experiment station of the United States Bureau of Mines, when some roaches were kept for several days in an atmosphere of over 60 per cent carbon monoxide and 20 per cent oxygen without lessening their activities.

The victim of acute carbon monoxide poisoning usually experiences the following symptoms: Yawning, sleepiness, weariness, and a feeling of constriction across the forehead; frontal headache, at first dull and intermittent, later continuous and more severe; this headache is replaced or masked by the typical headache of carbon monoxide poisoning, at the base and back of the skull, which causes the sufferer to hold his head as far back as possible in an effort to obtain relief; dizziness, nausea (feeling of sickness), and lassitude also occur. The pulse is at first normal, but later becomes full and rapid, the skin is flushed, the respiration becomes more rapid as exposure to the gas continues, and later becomes irregular. If the exposure is sufficiently long, or the concentration of carbon monoxide is sufficiently great, confusion and unconsciousness develop. As the victim recovers, he remains weak for sometime. This weakness persists especially in the muscles of his legs. A headache, sometimes very severe, confusion, and partial loss of memory accompany recovery, but pass off in time. The nausea may be sufficient to produce vomiting. All the symptoms are accentuated by exercise, eating, and stimulants. When a person is overcome by large concentrations, the symptoms follow each other rapidly and he may fall quickly unconscious. The rate at which a person is overcome and the sequence in which the symptoms appear depend on several factors, viz, the concentration of the gas; the extent of physical exertion; the state of his health and individual predisposition; and the temperature, humidity, and air movement to which he is exposed. Exercise high temperature, and great humidity, with no air movement, tend to increase respiration and heart rate, and consequently, result in more rapid absorption of carbon monoxide.

In chronic exposures, carbon monoxide poisoning produces a tired feeling, headaches, nausea, palpitation of the heart, sleeplessness, and sometimes mental dullness. Some persons develop a "tolerance" for carbon monoxide and may, after repeated exposures, be able to "stand" more of the gas than when first exposed to it. In the treatment of the chronic form of poisoning the most important factors are the removal of the patient from further exposure to carbon monoxide, and a thorough rest. Though there are probably many more cases of the chronic form than are usually recognized, it is in the treatment of the acute form that interest is generally centered.

The first and most important thing in caring for a case of acute carbon monoxide poisoning is to get the poison out of the blood as rapidly as possible. Every moment during which oxygen is shut out of the hemoglobin adds to the chances of failure of heart and respiration. Every minute during which the tissues are supplied with only a part of their needed oxygen increases the danger of their subsequent degeneration and permanent damage. Both to save life itself and to prevent ill health in the future, it is of vital importance to eliminate carbon monoxide from the blood as rapidly as possible.

Oxygen will replace carbon monoxide in combination with hemoglobin whenever the proportion of oxygen in the lungs is overwhelmingly greater. The speed of the change depends on the relative amounts of the two gases in the lungs and on the depth and frequency of breathing. The first step is to get the victim away from the atmosphere of carbon monoxide which he is breathing; the next is to supply him with oxygen. The first may be done by getting the patient into fresh air, but only one-fifth of air is oxygen. If a tank of pure oxygen is available, it is far better to use it as the action is much faster and the aftereffects, especially the headache, are much less severe and not so prolonged. The oxygen should, if possible, be given through an inhaler similar to an anesthetic mask or the Tissot army face mask, which can be fastened over the patient's mouth and nose, or entire face. If an inhaler is not at hand, a physician may give oxygen through a nasal catheter. In the absence of any of these accessories, it can be sprayed directly from the tank about the patient's face. It should be started as soon as he is removed from the carbon monoxide or before, if possible, and should be kept up for at least 20 minutes.

It may be that when the victim is found his breathing has stopped, or is very weak and irregular. In this case one of the rescuers should begin artificial respiration at once, by the Schaefer method as follows:

Place the person¹ on his abdomen; remove from his mouth all foreign bodies, such as false teeth, tobacco, and gum; see that the tongue is forward; turn his head to one side and rest it on his forearm, so that the mouth and nose will not come in contact with the ground, and extend the other arm forward. If the person is thin, prepare a pad of folded clothing, or blankets, and place it under the lower part of his chest. Do not make this pad too thick. Do not wait to loosen the victim's clothing, but begin artificial respiration without delay. An assistant may remove all tight clothing from the victim's neck, chest, and waist, and place blankets, hot-water bottles, safety lamps, or hot bricks, well wrapped in paper or cloth, about the person.

¹ Manual of First Aid Instruction for Miners. Bureau of Mines. 1921.

Kneel, straddling the person's thighs and facing his head. The palms of your hands are placed over the short ribs, with your thumbs parallel with the spine about 2 inches apart and your fingers spread out as much as possible, the ends of the little fingers reaching just below the last rib. With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear on the person. This operation, which should take about two seconds, must not be violent, lest the internal organs be injured. The lower part of the chest and also the abdomen are thus compressed and air is forced out of the lungs. Now, immediately swing back slowly to remove the pressure, but leave your hands in place. Through their elasticity the patient's chest walls expand and his lungs are thus supplied with fresh air. After two seconds swing forward again and repeat deliberately about 15 times a minute.

Continue if necessary for at least three hours without interruption, or until natural breathing has been restored or a physician has arrived. Even after natural breathing begins, carefully watch that it continues. If it stops, start artificial respiration again.

Although the administration of oxygen is by far the most important factor in the treatment and can not be overemphasized, other things should be done to help the patient. He should be kept *quiet* and *lying flat*, to help his weakened heart. As he gets better, he should *never* be allowed to walk about or in any way exert himself, for there is danger of heart failure. Heat from safety lamps, hot-water bottles, or warm bricks, rubbing the arms and legs, and keeping the patient well covered with blankets all help the circulation and aid in tiding the body over a period of low vitality. The safety lamps, hot bricks, etc., should be well wrapped in cloth or paper as a precaution against burning the patient. Other stimulants, such as hypodermics of caffein-sodium benzoate or camphor in oil, may be used only by a physician, and after he has considered the possibility of overstimulation and consequent collapse. The patient should be kept in bed for a day at least. Later he should be treated as a convalescent, being given plenty of time to rest and recuperate. Just how long this should be depends on the severity of his poisoning and should be decided by his physician.

SUMMARY OF TREATMENT.

1. Administer oxygen as *quickly as possible*, and in as pure form as is obtainable, preferably from a cylinder of oxygen through an inhaler mask.
2. Remove patient from atmosphere containing carbon monoxide.
3. If breathing is feeble, at once start artificial respiration by the prone posture method.
4. Keep the victim flat, quiet, and warm.
5. Afterwards give plenty of rest.